APPLICATIONS FOR SUBSTANCE ENCAPSULATING LAMINATE WEB

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CROSS REFERENCE TO RELATED APPLICATIONS

This application is: a continuation-in-part and claims priority of prior application PCT International Application Serial No. US00/34746 (Case 7897R2) which designates the US, will publish in English, and was filed December 20, 2000 in the names of Curro et al.; and a continuation-in-part and claims priority of prior application Serial No. 09/584676 (Case 7897R2), filed May 31, 2000 in the names of Curro et al.; and a continuation-in-part and claims priority of prior application Serial No. 09/467938 (Case 7897), filed December 21, 1999 in the names of Curro et al.

FIELD OF THE INVENTION

This invention relates to product applications for substance encapsulating laminate webs. More particularly, this invention to a laminate web wherein at least two outer layers sandwich or encapsulate a powdered, granular, particulate, or gel substance or a central layer. In preferred embodiments, the multilayer laminate web is apertured.

BACKGROUND OF THE INVENTION

Laminate webs formed by the joining of discrete webs in a layered relationship are well known in the art. For example, often laminate nonwoven webs are utilized in disposable absorbent articles such as diapers and adult incontinence products. Such laminated webs can be used as a topsheet, backsheet, or side panels. One example of a laminate web is a film/nonwoven laminate useful for a stretch side panel of a disposable diaper. Nonwoven/nonwoven laminates are also utilized to provide additional bulk or softness to a web component. Likewise, film/film laminate webs can provide benefits by combining the characteristics of various films in a layered relationship. Laminate webs can also be called composite webs.

Less common examples of laminate webs include laminates of dissimilar materials. The materials may be dissimilar in mechanical tensile properties, thermal properties, or visual/tactile properties. For example, a nonwoven web may be joined to a relatively stiff fabric to provide for a soft surface feel to the fabric. The dissimilar materials may be joined by melt bonding, adhesive bonding, ultrasonic bonding, and the like. Bonding

methods are often determined by the materials themselves, but often require adhesive bonding. For example, a laminate or composite of materials having widely differing melt properties may require an adhesive layer between laminate layers. Even materials having similar melt properties, such as nonwoven and thermoplastic film materials are often joined by adhesive for adequate bonding to prevent unwanted delamination. Although adhesive may be necessary, such processing methods can be expensive due to the addition of adhesive, and the resulting laminate is often relatively stiff, depending on the laminate materials and the level of adhesive added.

Often laminate webs are intended to combine properties of the constituent layers to achieve synergistic benefits. For example, EP-B-715,571 issued to Wadsworth discloses a multilayered nonwoven composite web intended for use as a substitute for a woven web such as a textile web. The web comprises at least a layer of thermoplastic man-made fibers and a layer of cellulose-based fibers. The cellulose-based fiber layer is disclosed as thermally bonded to the thermoplastic man-made fiber layers at spaced apart locations. However, it appears that thermal bonding between both, or all, the layers is necessary to produce the requisite bonding.

EP-A-112,654 issued to Haq, et al. discloses a laminate comprising two sheets of nonwoven fabric or the like having sandwiched between them a solid core material which may be a highly porous, optionally liquid-containing, polymer. The two outer sheets are bonded to each other, without involving the core material, by means of a plurality of small, spaced bonding points, for example, spot-welds. Preferably the core material is in continuous sheet form and is perforated to accommodate the bonding points. However, it appears it would present a significant processing problem to register the perforations of the core material in order to have the outer layers bonded therethrough.

For many purposes it is desirable to have an apertured nonwoven web, the apertured web being characterized by a plurality of openings, or perforations, in the web. Such apertures can provide for an open mesh appearance, as well as beneficial texture and cloth-like properties. Such apertured nonwoven webs can be made by methods known in the art. For example, EP-B-164,740 issued to Shimalla discloses an apertured non-woven fabric comprising a web of thermoplastic fibers is described. The fabric is formed with a multiplicity of fused patterned regions and adjacent substantially non-fused regions, there being apertures formed within a plurality of the fused patterned regions but not within the adjacent regions. The fabric is produced by heat embossing a non-woven web of thermoplastic fibers at a temperature above the softening point of the fibers whereby the regions of the web compressed by the projections of the embossing means become fused, and immediately thereafter drafting the embossed web so that apertures are formed in the

fused patterned regions. However, it is not apparent that the method disclosed would produce a laminate of nonwoven webs, or a laminate of dissimilar materials.

Another beneficial method of aperturing a nonwoven web, including laminates of nonwoven webs is disclosed in EP-A-852,483, issued to Benson et al. Disclosed is a laminate material having, for example, at least one layer of a spunbonded web joined to at least one layer of a meltblown web, a bonded carded web, or other suitable material. Such apertured webs are useful as the topsheet in a disposable absorbent article. However, this disclosure does not teach laminating webs comprising dissimilar materials (e.g., materials of different material classes or having differing material properties).

A perforated multilayer elastic coversheet comprising an intermediate elastic layer between upper and lower nonwoven layers is disclosed in EP-A-784,461 issued to Palumbo. The upper and lower layers are connected to the intermediate layer only around the perimeters of the perforations. While providing an apertured, elastic laminate, it is not apparent that the method disclosed could produce laminates comprising thermally-dissimilar materials.

As mentioned, nonwoven webs are beneficial components of consumer products, which can include disposable absorbent garments, non-absorbent disposable garments, durable garments, automotive components, upholstered furniture, filtration media, and other consumer or commercial goods. Nonwovens used in these and other applications benefit from their wide range of visual and tactile properties. However, in many cases, the nonwovens used could benefit from being a carrier for other ingredients. For example, it would be beneficial to have a laminate web that is capable of delivering active substances, such as perfumes or insect repellents. Or the laminate web could simply be a carrier for components such as seeds for agricultural use, or odor controlling substances.

Accordingly, it would be desirable to have laminate web carriers of encapsulated substances.

Additionally, it would be desirable to have laminate webs of dissimilar material properties which are not dependent upon thermal compatibility of each constituent layer for structural integrity, and which are capable of providing an additional benefit beyond simple visual and tactile properties.

BRIEF SUMMARY OF THE INVENTION

A substance encapsulation system disclosed. The system comprises a first web and a second web, the first and second webs joined to one another in a face-to-face relationship by at least one bond site defining an elongated melt weakened region having an aspect ratio of at least about 2. The bond site has a longitudinal axis oriented in a first

direction and a transverse axis oriented in a second direction orthogonal to the first direction. A powdered, granular, particulate, or gel substance can be disposed between the first and second webs. Upon application of a sufficient force having a vector component parallel to the transverse axis, the bond site fractures to form a corresponding aperture to facilitate exposure of the substance. Alternatively, a central layer may be disposed between at least a portion of the first and second webs. The central layer may carry a substance to be exposed or the central layer may be a dissimilar material from the first and second webs. In a preferred embodiment the system has a plurality of bond sites.

BRIEF DESCRIPTION OF THE DRAWINGS

While the specification concludes with claims pointing out and distinctly claiming the present invention, it is believed the same will be better understood by the following drawings taken in conjunction with the accompanying specification wherein like components are given the same reference number.

FIG. 1 is a perspective of one embodiment of a laminate web of the present invention.

FIG. 2 is a cross-sectional view of a portion of the laminate web shown in Figure 1.

FIG. 3 is a magnified detail view of one bond site of a laminate web of the present invention.

FIG. 4 is a top plan view of another embodiment of the laminate web of the present invention.

FIG. 5 is a cross-sectional view of a portion of the laminate web shown in Figure 4.

FIG. 6 is a top plan view of another embodiment of the laminate web of the present invention.

FIG. 7 is a cross-sectional view of a portion of the laminate web shown in Figure 6.

FIG. 8 is a photomicrograph of one embodiment of a laminate web of the present invention.

FIG. 9 is a schematic representation of a process for making a laminate web of the present invention.

FIG. 10 is a perspective view of a melt bond calendaring apparatus.

FIG. 11 is a schematic representation of a pattern for the protuberances of the calendaring roll.

FIG. 12 is a perspective view of an apparatus for stretching a laminate of the present invention to form apertures therein.

FIG. 13 is a cross-sectional view of a portion of the mating portions of the apparatus shown in FIG. 12.

FIG. 14 is a photograph showing a representative nonwoven web having consolidation bonds and high aspect ratio bond sites.

DETAILED DESCRIPTION OF THE INVENTION

As used herein, the term "absorbent article" refers to devices which absorb and contain body exudates, and, more specifically, refers to devices which are placed against or in proximity to the body of the wearer to absorb and contain the various exudates discharged from the body.

The term "disposable" is used herein to describe articles that are not intended to be laundered or otherwise restored or reused (i.e., they are intended to be discarded after a single use and, preferably, to be recycled, composted or otherwise disposed of in an environmentally compatible manner). The term "durable" as used herein refers to articles that are not disposable.

As used herein, the term "nonwoven web" is used in its plain meaning as understood in the art and refers to a web that has a structure of individual fibers or threads which are interlaid, but not in any regular, repeating manner. Nonwoven webs have been, in the past, formed by a variety of processes, such as, for example, meltblowing processes, spunbonding processes and bonded carded web processes.

As used herein, the term "microfibers", refers to small diameter fibers having an average diameter not greater than about 100 microns.

As used herein, the term "meltblown fibers", refers to fibers formed by extruding a molten thermoplastic material through a plurality of fine, usually circular, die capillaries as molten threads or filaments into a high velocity gas (e.g., air) stream which attenuates the filaments of molten thermoplastic material to reduce their diameter, which may be to a microfiber diameter. Thereafter, the meltblown fibers are carried by the high velocity gas stream and are deposited on a collecting surface to form a web of randomly dispersed meltblown fibers.

As used herein, the term "spunbonded fibers" refers to small diameter fibers that are formed by extruding a molten thermoplastic material as filaments from a plurality of fine, usually circular, capillaries of a spinneret with the diameter of the extruded filaments then being rapidly reduced by drawing.

As used herein, the term "unitary web" refers to a layered web comprising two or more webs of material, including nonwoven webs, that are sufficiently joined, such as by thermal bonding means, to be handled, processed, or otherwise utilized, as a single web.

As used herein, "laminate" and "composite" when used to describe webs of the present invention, are synonymous. Both refer to a layered web structure comprising at least two webs joined in a face-to-face relationship to form a multiple-layer unitary web.

As used herein, the term "encapsulate" is used to refer to physical immobilization and covering, such as by trapping between two layers of web material, and does not refer to complete, isolated coverage, such as by hardcoating.

As used herein, the term "polymer" generally includes, but is not limited to, homopolymers, copolymers, such as, for example, block, graft, random and alternating copolymers, terpolymers, etc., and blends and modifications thereof. Furthermore, unless otherwise specifically limited, the term "polymer" shall include all possible geometrical configurations of the material. These configurations include, but are not limited to, isotactic, syndiaotactic and random symmetries.

As used herein, the term "elastic" refers to any material which, upon application of a biasing force, is stretchable, that is, elongatable, at least about 60 percent (i.e., to a stretched, biased length, which is at least about 160 percent of its relaxed unbiased length), and which, will recover at least 55 percent of its elongation upon release of the stretching, elongation force. A hypothetical example would be a one (1) inch sample of a material which is elongatable to at least 1.60 inches, and which, upon being elongated to 1.60 inches and released, will recover to a length of not more than 1.27 inches.

Many elastic materials may be elongated by more than 60 percent (i.e., much more than 160 percent of their relaxed length), for example, elongated 100 percent or more, and many of these materials will recover to substantially their initial relaxed length, for example, to within 105 percent of their initial relaxed length, upon release of the stretch force. Such materials are denoted herein by the term "highly elastic" which refers to any material which upon application of a biasing force, is stretchable, that is, elongatable, at least about 200 percent (i.e., to a stretched, biased length, which is at least about 300 percent of its relaxed unbiased length), and which, will to within 105 percent of their initial relaxed length, upon release of the stretch force. Therefore, highly elastic materials are generally also elastic, but not all elastic materials are highly elastic.

As used herein, the term "nonelastic" refers to any material that does not fall within the definition of "elastic" above.

As used herein, the term "extensible" refers to any material that, upon application of a biasing force, is elongatable, at least about 25 percent without experiencing catastrophic failure. Catastrophic failure includes substantial tearing, fracturing, rupturing, or other failure in tension such that, if tested in a standard tensile tester, the failure would result in a sudden significant reduction in tensile force. As used herein, the

term "highly extensible" refers to any material that, upon application of a biasing force, is elongatable, at least about 100 percent without experiencing catastrophic failure.

The Laminate Web

The laminate web **10** of the present invention comprises at least three layers or plies, disposed in a layered, face-to-face relationship, as shown in FIG. 1. The layers should be sufficiently thin to be processible as described herein, but no actual thickness (i.e., caliper) is considered limiting. A first outer layer **20** is preferably thermally bondable, and is preferably a nonwoven web comprising a sufficient quantity of thermoplastic material, the web having a predetermined extensibility and elongation to break. By "sufficient quantity" is meant a quantity of thermoplastic material adequate to enable enough thermal bonding upon application of heat and/or pressure to produce a unitary web. A second outer layer, **40**, is preferably the same material as first outer layer **20**, but may be a different material, also being thermally bondable and having a predetermined extensibility and elongation to break. At least one third central layer **30** is disposed between the two outer layers. The central layer **30** can be a substance, or a carrier for a substance that is encapsulated by first and second layers **20** and **40**.

The laminate web **10** is processed by joining means, such as by ultrasonic welding, or thermal calendaring as described below to provide at least one, and preferably a plurality of, melt bond sites **50** that serve to couple the outer layers **20** and **40**, and, in some embodiments, portions of central layer **30**, thereby forming the constituent layers into a unitary web. When joined together, the two outer layers form an interior region **80** between them. The interior region **80** is the space between the outer layers surrounding the bond sites **50**. In a preferred embodiment, the third central layer **30** substantially fills the interior region, the third central layer **30** being apertured coincident the bond sites **50**.

One representative bond site is shown in FIG. 3. As shown, bond site **50** has an elongated shape, with a longitudinal axis **l**, which corresponds directionally to the length dimension, **L**, of bond site **5**, and a transverse axis **t**, which is perpendicular to longitudinal axis **l**, and corresponds directionally to the width dimension, **W** of bond site **5**. For non-limiting descriptive purposes, the bond site **5** can be considered to be two-dimensional, with the axes **l** and **t** defining a plane of the bond site **5**.

While the laminate web **10** is disclosed primarily in the context of nonwoven webs and composites, in principle the laminate web **10** can be made out of any web materials that meet the requirements, (*e.g.*, melt properties, extensibility) as disclosed herein. For example, the outer layers **20** and **40** can be thermoplastic films, micro-porous films, apertured films, woven fabrics, and the like. Central layer **30** can comprise paper,

including tissue paper; metal, including metal foil; other non-thermoplastic web material, woven fabric, and the like. In general, it is required that outer layer materials be flexible enough to be processed as described herein. However, central layer can comprise a brittle, relatively stiff material, as long at it also can be processed as described herein, albeit possibly becoming fractured, broken, or otherwise broken up in the process. One of the unexpected advantages of the present invention, therefore, is the discovery that novel substance encapsulation properties can be exhibited by the choice of central layer **30** disposed between the two outer layers.

Non-Apertured Embodiment

In one embodiment, as shown in cross-section in FIG. 2, central layer **30** can be apertured, without aperturing the two outer layers to provide a three-layer laminate characterized by the laminate web **10** (as a whole) being un-apertured, while the central layer **30** is apertured. Importantly, the web of the present invention can be made by the method of the present invention without requiring registration of the layers to ensure bonding of the outer layers through the apertures of the central layer(s). One way of describing a preferred embodiment of a web **10** as described above, is that the unitary web **10**, when viewed orthogonally by the un-aided human eye from a distance of approximately 50 cm, exhibits no apertures or perforations through the entire laminate, but bond sites **50** are nevertheless visible.

The laminate web **10** is further characterized in that the joining of the three plies into a unitary web can be achieved in the absence of adhesive. That is, in certain preferred embodiments no adhesive is required to bond the layers together; joining is achieved by the input of energy into the constituent layers, such as by thermal melt bonding of the two outer layers together at the melt bond sites **50**. In other embodiments, the energy input can be via ultrasonic bonding. Accordingly, a significant benefit of the present invention is the provision of a laminate web, that is a unitary web, formed without the use of adhesives. Not only does this simplify processing and lower the cost of the laminate web, when certain materials such as nonwoven webs are used, it results in a more flexible, softer web.

As shown in FIG. 2, central layer **30** is chosen such that when the constituent web layers of laminate web **10** are processed by the method of the present invention, portions of central layer **30** in the region of the melt bond sites **50** separate to permit the first outer layer **20** to melt bond directly to the second outer layer **40** at the interface of the two materials **52** at melt bond sites **50**. Thus, apertures in the central layer **30** are formed in the lamination step by displacement, just prior to the bonding of the outer layers as

detailed by the method of the present invention below. In this manner, central layer **30** can be provided as an unapertured web, avoiding complex registration steps to align apertures in registry with bond sites when laminated.

Further, central layer **30** and/or the substances carried in or on it, need not be thermally compatible with outer layers **20** and **40**. Central layer need not be a thermoplastic material, and need not even have a melting point. It simply needs to be displaceable by the forces exerted by the processing equipment as detailed below. The central layer **30** can be, for example, a cellulosic material, such as paper; a metallic material, such as a metal foil; a woven or knit material, such as cotton or rayon blends; or a thermoset material, such as polyester or aromatic polyamide film.

Therefore, one way of describing the laminate web of the present invention is to distinguish the central layer as being a material differentiated from the materials of the first or second layers by at least one material property selected from thermal properties, elongation properties, elastic properties, or conductive properties. By "thermal properties" is meant primarily thermal melt properties, such that the central layer has no melting point, or if it has a melting point, it is preferably at least about 10 degrees Centigrade higher, more preferably about 20 degrees Centigrade higher than either outer layer, and can be 100 degrees Centigrade higher than either outer layer. By "elongation properties" is meant that in tension, the material of the central layer exhibits an elongation to break that is at least 10% less than either outer layer, more preferably 50% less than either outer layer, and can be greater than 100% less than either outer layer. Thus, the central layer can be extensible, while either outer layer can be highly extensible. By "elastic properties" is meant that the central layer can be, for example, elastic, while either outer layer can be highly elastic, as defined herein. Or the central layer can be non-elastic, and the outer layers elastic or highly elastic. By "conductive properties" as used herein is meant electrically conductivity, such that the central layer can have an electrical conductivity that is 10 times, and more preferably 100 or more times as great as the outer layers. Conductive properties may be facilitated by the central layer being a metallic foil, or by being a conductive polymer, including a conductive nonwoven web.

Another advantage of the method of the present invention is that, in some embodiments, e.g., for solid core central layer **30** materials (i.e., a continuous sheet, that is, not having substantial apertures, gaps, or other voids), it results in a unitary web having an apertured central layer **30** in full, intimate contact with the outer layers **20**, and **40**. By "full" and "intimate" is meant that central layer **30** fills all the unbonded region **80** between outer layers **20** and **40** such that outer layers **20** and **40** do not contact except at the bond sites **50**. Of course, it is recognized that many materials of interest have

significant air content, and filling "all" the unbonded region between outer layers **20** and **40** is not meant to imply that all air content is removed.

Central layer **30** can be involved, or participate, in the bonding between outer layers **20** and **40**. By "involved" is meant that the central layer can, to some extent, be in intimate contact with, and possibly partially merged with, one or both immediate outer layers. The involvement may be due to actual melt bonding about the perimeter of bond site **50** (e.g., for thermoplastic central layers **30**), or it may be due to mechanical interaction, such as by entanglement (e.g., for cellulosic fibrous central layer **30** between fibrous nonwoven layers), also about the perimeter of bond site **50**.

Without being bound by theory, it is believed that the process of the present invention facilitates such separation of central layer **30** by shearing, cutting, or otherwise fracturing the central layer **30**, and displacing the material of the central layer **30** sufficiently to permit thermal bonding of the two outer layers **20** and **40**. Thus, central layer **30** must be chosen to have properties that permit such displacement. Therefore, central layer **30** should have one or more of the properties such that the material of central layer **30** can be "squeezed" or otherwise displaced out of the region of thermal bond sites **50**. Importantly, it is not required that the central layer **30** be melted out of the region of the thermal bond sites. Thus, central layer can be elastic, highly elastic, extensible, or highly extensible, depending on the desired end results and purposes of the resulting unitary web.

Without being bound by theory, it is believed that to accomplish the displacement of central layer **30** to form apertures therein and to bond the outer layers, the thermal point calendaring described below should form thermal bond sites having a narrow width **W** dimension and a high aspect ratio. For example, FIG. 3 shows the melt area of a single melt bond site **50** having a narrow width dimension **W** and a high aspect ratio, *i.e.*, the length, **L**, is much greater than the width, **W**. The length **L** should be selected to permit adequate bond area while width **W** is sufficiently narrow such that the protuberance used to form the bond site (as described below) can cut, shear, displace, or otherwise pierce the central layer **30** at the region of the bond sites by the method described below. Width **W** can be between about 0.003 inches and 0.020 inches, but in a preferred embodiment, is between about 0.005 inches and 0.010 inches, and may be adjusted depending on the properties of central layer **30**.

It is believed that the aspect ratio of melt bond site **50** can be as low as about 2 (i.e., ratio of **L/W** equals 2/1). It can also be between about 3 and 100 or between about 3 and 50 or preferably between about 4 and 30. In one preferred embodiment, the aspect ratio was about 10 and in another embodiment about 25. It is believed that the aspect ratio of

the melt bond sites **50** is limited only by the corresponding aspect ratio of the point bonding protuberances of the calendaring roller(s), as detailed below.

In a preferred embodiment, the longitudinal axis of each bond site, **l**, which corresponds directionally to the length dimension of bond site **50**, is disposed in a regular, repeating pattern oriented generally parallel to the machine direction, **MD** as shown in FIG. 1. But the longitudinal axis of each bond site may be disposed in a regular, repeating pattern oriented in the cross machine direction, or randomly oriented in a mixture of cross and machine directions. For example, the bond sites **50** can be disposed in a "herringbone" pattern in which a first portion of bond sites **50** would each have their respective longitudinal axes oriented in a first direction, and a second portion of bond sites **50** would likewise have their respective longitudinal axes oriented in a second direction, which is disposed at an angle to the first direction.

When nonwoven webs are used as constituent layers of laminate **10**, an important distinction should be drawn between bond sites **50** that bond together outer layers **20** and **40** by the method of the present invention, and thermal bond sites that may be present in the constituent webs themselves. For example, nonwoven webs are typically consolidated by thermal bonding in a regular pattern of discrete spaced apart fused bonding areas, such as the pattern disclosed in U.S. Pat. No. 3,855,046 to Hansen et al., and the patterns shown generally in FIGs. 10 and 11 of U.S. patent 5,620,779 to Levy et al. Other films, nonwoven webs, and the like may have thermal embossments for aesthetic reasons. Therefore, in the unitary web **10** there may be many thermal bond sites, some of which are bond sites **50**, and others which are bond sites in the base nonwoven, for example. This distinction can clearly be seen in the photograph of FIG. 14 showing a representative nonwoven web having diamond-shaped consolidation bonds and high aspect ratio bond sites **50**.

As shown in FIG. 14, the bond sites of the base nonwoven do not typically have an aspect ratio greater than about 1, so that these bonds rarely, if ever, form apertures in the constituent layer during the stretching step disclosed below. Also, the spacing of such bond sites is typically a repeating pattern of bonded and unbonded area that may or may not provide for machine direction (MD) columns of bonded area next to columns of unbonded area. After forming bond sites **50**, however, there is not likely to be any significant MD columns of unbonded areas; the overall bond pattern of any constituent nonwoven fabric is a combination of existing bonded areas and bond sites **50**. Together the two sets of bond sites result in a complex pattern of bond sites that may, but most likely cannot, be described as columnar, regular, or uniform.

The resulting web of the present invention, as shown in cross-section in FIG. 2, is a laminate web **10** that is itself unapertured, but the central layer **30** is apertured coincident the regions of the bond sites **50**. As stated above, by "unapertured" is meant that, on the whole, the laminate web **10** is considered unapertured. It is recognized that the un-apertured laminate web **10** of the present invention may have localized cut through, or tearing at bond sites **50** due to materials and processing variability or post lamination handling. Ideally, such cut through of the entire web is minimized and eliminated. Likewise, it is recognized that in some instances, there may not be complete displacement of the central layer **30** at all locations of bond sites **50** such that some localized portions of central layer **30** may not be apertured (and the outer layers not bonded). Nevertheless, the description herein is made for the laminate web **50** as a whole, and is not meant to be limited by aberrations or anomalies due to potential material or processing variables.

To produce the webs of the present invention, including as described with respect to FIG. 2, the outer layers should have sufficient elongation to permit the necessary local deformation in the immediate vicinity of bond sites **50**. Thus, the outer layers **20** and **40** can be extensible, highly extensible, elastic, or highly elastic.

In general, according to the present invention, the central layer **30** can be a carrier for an active substance, or a substance to be exposed to the exterior of the laminate. For example, plant seeds can be disposed on central layer and immobilized, or otherwise held in a uniform spaced relationship, such that the laminate encapsulates the seeds for storage and ready planting. In this case, it is desirable that each of the layers be degradable. Alternatively, other agriculturally-beneficial substances, such as fertilizer, insecticide, moisture absorbing/releasing compounds, heat absorbing/releasing compounds, and the like, can be disposed on, in, or otherwise as part of, central layer **30**.

Alternatively, odor-controlling substances, such as activated charcoal, or activated carbon fibers, such as BESFIGHT® PAN-based carbon fibers from Toho Rayon, Japan can be disposed in sufficient amounts on or in central layer **30**. Other odor-controlling substances can be utilized, such as an absorbent tissue impregnated with an odor-controlling liquid substance. An example of such a product includes a three-layer laminate of nonwovens encapsulating a central layer of a web comprising BOUNTY® paper towels having FEBREEZE® odor absorbing media absorbed therein. The outer nonwoven layers can serve to limit evaporation of the odor absorbing media.

Without being bound by theory, it is believed that any powdered, granular, particulate, or gel material that can withstand the thermal bonding process described below can be included as, or as part of, central layer **30**, and as such, is encapsulated by outer layers **20** and **40**. Thus, without limitation, microspheres of known varieties can be

included in central layer **30**, as well as phase change materials (PCM) such as OUTLAST® Temperature Regulation technology available form Outlast Technologies, Boulder CO. Edible substances including food products, such as coffee, tea, flavorings, colorants, and the like can be supplied on, in, or as central layer **30**.

If central layer **30** has a melting point, it is preferably at least about 10 degrees Centigrade higher, more preferably about 20 degrees Centigrade higher than the outer layers. In certain embodiments, for example a metal foil central layer **30** between thermoplastic nonwoven outer layers, the central layer can have a melting point at least 100 degrees Centigrade higher than the outer layers. However, central layer **30** need not have a melting point, and may simply experience softening at the calendaring temperatures required to bond the laminate. In certain central layer materials, such as metal foils, there may not be any softening due to thermal processing of the web.

The wide range of possible central layer carrier materials permits a surprising variety of structures of the present invention, each having beneficial application in a wide assortment of end uses. For example, if a central layer of tissue paper is used, the resulting laminate is a soft, bulky, absorbent web. Such a laminate is suitable for use as a wiping implement having a cleaning substance disposed therein, for example. Further, since the laminate web **10** is formed without the use of thermoplastic adhesives, durable, garment-like properties can be obtained. Such laminates can be laundered a number of times before suffering unacceptable wear.

By way of example, laminate web **10** can be a conductive fabric comprising relatively non-conductive thermoplastic outer layers **20** and **40** and a relatively conductive central layer **30**. The outer layers can be non-woven webs for a low cost, soft, breathable conductive fabric. The central layer can be a metal foil, such as a copper foil or an aluminum foil, or a flexible web having powdered conductive material disposed thereon. For example, powdered nickel or silver can be applied by methods known in the art to form a uniform layer over central layer **30**, which can be a paper or nonwoven carrier layer. One suitable nickel powder can be commercially supplied by INCO Specialty Products, Inco Limited, Wyckoff, NJ. The central layer can also be a conductive polymer, a non-foil conductive fabric, or a composite conductive material. In general, as a conductive fabric embodiment, the outer layers should serve to insulate the conductive central layer(s). In a preferred three-layer embodiment the outer layers each have a first electrical resistance and the central layer has a second electrical resistance that is at least one-tenth the first electrical resistance, more preferably one-hundredth (i.e., the central layer is 10 times, preferably 100 times as conductive as the outer layers).

A further benefit of the present invention is the capability to combine both thermoplastic and non-thermoplastic materials without any adhesives, to provide fabric-like composites having unique physical properties. For example, a material having high tensile strength and resistance to tear can include as a central layer **30** TYVEK®, available from DuPont, Wilmington Delaware, USA. TYVEK®, and equivalent or similar materials under other tradenames, is an extremely strong but breathable polyolefin nonwoven, commonly used as a house-wrap layer. However, it is not soft and clothlike, but has the look and feel of a plastic film. When used in a laminate web **10** of the present invention, for example with nonwoven outer layers, the laminate web exhibits the softness of a nonwoven with the strength of the TYVEK® layer. Again, this laminate can be, and is preferably, made without the use of adhesives to bind the web into a unitary web.

Further, relatively strong materials such as TYVEK® can be combined with additional central layers **30** to make laminate webs **10** having a variety of physical properties. For example, a laminate web comprising a TYVEK® layer can also comprise an absorbent layer, such a layer of absorbent tissue paper, such as BOUNTY® paper towel, available from The Procter & Gamble Co., Cincinnati Ohio, USA and one or more outer layers of polyethylene nonwoven (e.g. Corolind, available from BBA, Simpsonville, S.C., USA). Such a composite formed according to the method of the present invention can be transformed into a highly textile-like material, exhibiting the unusual combined properties of relatively high absorbency (from the BOUNTY® paper towel layer(s)), and relatively high strength (from the TYVEK® layer(s)).

<u>Apertured Embodiments</u>

A further benefit of the present invention is obtained when the non-apertured thermally bonded laminate web described above is stretched or extended in a direction generally orthogonal to the longitudinal axis, **l**, of melt bond sites **50** to form apertures. That is, upon application of a sufficient force having a vector component parallel to the transverse axis **t**, the bond site **50** fractures to form a corresponding aperture, which serves to facilitate exposure of an encapsulated substance substance.

The melt bonding at the melt bond sites **50** tends to make localized weakened portions of the web at the bond sites. Thus, as portions of the web **10** are extended in a direction generally orthogonal to the longitudinal axis **l** of bond sites **50**, the material at the bond site fails in tension and an aperture is formed. The relatively high aspect ratio of melt bond sites **50**, permits a relatively large aperture to be formed upon sufficient

extension. When the laminate web **10** is uniformly tensioned, the result is a regular pattern of a plurality of apertures **60** corresponding to the pattern of melt bond sites **50**.

FIG. 4 shows a partially cut-away representation of an apertured laminate of the present invention. As shown, the partial cut-away permits each layer or ply to be viewed in a plan view. The laminate web **10** shown in FIG. 4 is produced after the thermally bonded laminate is stretched in a direction orthogonal to the longitudinal axis of the melt bond sites, in this case, in the cross-machine direction, **CD** with sufficient elongation in the direction of extension to cause apertures to form. As shown, where formerly were melt bond sites **50**, apertures **60** are produced as the relatively weak bond sites fail in tension. Also as shown, central layer **30**, and the substances thereon or therein, can remain generally uniformly distributed within laminate **10**, depending on the material properties of central layer **30**. For example, if central layer **30** is more extensible than outer layers **20** or **40**, then it simply extends, either elastically or by plastic deformation, but remains generally uniformly distributed in the unapertured regions of web **10**. For example, if a thermoplastic film is utilized as the central layer **30**, it extends, either extensibly or elastically (depending on the type of film), but can remain generally uniform, for example, in density or basis weight.

When apertures **60** are formed, the thermally bonded portions of outer layers **20** and **40** remain primarily on the portions of the aperture perimeters corresponding to the length dimension of bond sites **50**. Therefore, each aperture **60** does not have a perimeter of thermally bonded material, but only portions remain bonded, represented as **62** in FIG. 4. One beneficial property of such a laminate web is that once apertured, fluid communication with the central layer is facilitated. Thus, the encapsulated substance of central layer **30** can be released into, or exposed to, an exterior portion of the web. Thus, for example, seeds that were previously fully encapsulated, for example by two fluid impervious polymer films, can be exposed upon formation of apertures to moisture and soil. Other ingredients, including active ingredients can be likewise exposed to the environment to act in a beneficially predetermined manner. For example, a hydrophilic central layer **30** having encapsulated or absorbed cleaning fluid can be used between two relatively hydrophobic outer layers, and the laminate **10** could be an effective cleaning wiper with a relatively dry to the touch outer surface.

To the extent that central layer **30** is involved, or participates, in any bonding between outer layers **20** and **40**, it also participates in the remnant of bonded portions **62**, as shown in FIG. 4. The involvement may be due to some degree of actual melt bonding about the perimeter of bond site **50** (e.g., for thermoplastic central layers **30**), or it may be

extension. When the laminate web **10** is uniformly tensioned, the result is a regular pattern of a plurality of apertures **60** corresponding to the pattern of melt bond sites **50**.

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extension. When the laminate web **10** is uniformly tensioned, the result is a regular pattern of a plurality of apertures **60** corresponding to the pattern of melt bond sites **50**.

FIG. 4 shows a partially cut-away representation of an apertured laminate of the present invention. As shown, the partial cut-away permits each layer or ply to be viewed in a plan view. The laminate web **10** shown in FIG. 4 is produced after the thermally bonded laminate is stretched in a direction orthogonal to the longitudinal axis of the melt bond sites, in this case, in the cross-machine direction, **CD** with sufficient elongation in the direction of extension to cause apertures to form. As shown, where formerly were melt bond sites **50**, apertures **60** are produced as the relatively weak bond sites fail in tension. Also as shown, central layer **30**, and the substances thereon or therein, can remain generally uniformly distributed within laminate **10**, depending on the material properties of central layer **30**. For example, if central layer **30** is more extensible than outer layers **20** or **40**, then it simply extends, either elastically or by plastic deformation, but remains generally uniformly distributed in the unapertured regions of web **10**. For example, if a thermoplastic film is utilized as the central layer **30**, it extends, either extensibly or elastically (depending on the type of film), but can remain generally uniform, for example, in density or basis weight.

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To the extent that central layer **30** is involved, or participates, in any bonding between outer layers **20** and **40**, it also participates in the remnant of bonded portions **62**, as shown in FIG. 4. The involvement may be due to some degree of actual melt bonding about the perimeter of bond site **50** (e.g., for thermoplastic central layers **30**), or it may be

extension. When the laminate web **10** is uniformly tensioned, the result is a regular pattern of a plurality of apertures **60** corresponding to the pattern of melt bond sites **50**.

FIG. 4 shows a partially cut-away representation of an apertured laminate of the present invention. As shown, the partial cut-away permits each layer or ply to be viewed in a plan view. The laminate web **10** shown in FIG. 4 is produced after the thermally bonded laminate is stretched in a direction orthogonal to the longitudinal axis of the melt bond sites, in this case, in the cross-machine direction, **CD** with sufficient elongation in the direction of extension to cause apertures to form. As shown, where formerly were melt bond sites **50**, apertures **60** are produced as the relatively weak bond sites fail in tension. Also as shown, central layer **30**, and the substances thereon or therein, can remain generally uniformly distributed within laminate **10**, depending on the material properties of central layer **30**. For example, if central layer **30** is more extensible than outer layers **20** or **40**, then it simply extends, either elastically or by plastic deformation, but remains generally uniformly distributed in the unapertured regions of web **10**. For example, if a thermoplastic film is utilized as the central layer **30**, it extends, either extensibly or elastically (depending on the type of film), but can remain generally uniform, for example, in density or basis weight.

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To the extent that central layer **30** is involved, or participates, in any bonding between outer layers **20** and **40**, it also participates in the remnant of bonded portions **62**, as shown in FIG. 4. The involvement may be due to some degree of actual melt bonding about the perimeter of bond site **50** (e.g., for thermoplastic central layers **30**), or it may be

due to mechanical interaction, such as by entanglement (e.g., for cellulosic fibrous central layer **30** between fibrous nonwoven layers).

FIG. 5 is a schematic representation of the cross-section denoted in FIG. 4. As shown, apertures **60** form when the laminate web is elongated in the direction **T**.

Another benefit of the present invention is obtained when the laminate is extended as described with reference to FIG. 4, but the central layer **30** is chosen to have an elongation to break less than either of the two outer layers, and less than the actual magnitude of extension. Thus, upon extension of the laminate web generally orthogonal to the longitudinal axis, **l**, sufficient to form apertures in outer layers **20** and **40** (and thus the entire laminate web **10**) central layer **30** fails in tension. Therefore, central layer **30** fractures (i.e., fails in tension) upon sufficient extension, such that after extension central layer **30** is no longer uniformly distributed over the non-apertured regions of the laminate web **10**.

An example of one embodiment of a unitary web having a central layer having an elongation to break less than either of the two outer layers, and less than the actual magnitude of extension, is shown partially cut-away in FIG. 6. The partial cut-away permits each layer or ply to be viewed in a plan view. As shown, after extension, central layer **30** becomes fragmented, forming discontinuous regions of the central layer material. These discontinuous regions may be relatively uniformly distributed, such as in rows as shown in FIG. 6, or may be relatively randomly distributed, depending on the pattern of melt bond sites **50**, the physical properties of central layer **30**, and the method of extension employed.

One example of a web **10** having a structure similar to that shown in FIG. 6 is a web having outer layers of relatively extensible nonwovens, with a central layer of relatively low extensibility tissue paper. Such a laminate would be an apertured laminate web having an absorbent central core, wherein the absorbent core material is in fluid communication with regions exterior to the laminate web. That is, for example, if such a laminate web comprised nonwoven outer layers, it could be used as an absorbent wiper. Fluids could thus be absorbed via the apertures, the perimeter of which can be open at portions that provide fluid communication to the absorbent central core. If a relatively hydrophobic nonwoven web is used for the outer layers, such a wiper could exhibit dry-to-the-touch properties along with high absorbency.

One particularly interesting structure of a web **10** having a structure similar to that shown in FIG. 6 incorporates a highly hydrophobic outer layer combined with a highly absorbent central layer. A suitable hydrophobic material is described in U.S. Patent 3,354,022 Dettre et al. Such a material has a water repellent surface having an intrinsic

advancing water contact angle of more than 90 degrees and an intrinsic receding water contact angle of at least 75 degrees. Such a material exhibits extremely hydrophobic properties, similar to the effect known to exist on leaves from the Lotus plant. When such a material is combined with an absorbent central layer, such as a BOUNTY® paper towel tissue layer, the resulting composite can be highly absorbent while retaining a very clean and dry outer surface. The basis weight and porosity of the outer layer can be varied to achieve different degrees of absorbent performance. In one embodiment the laminate could also be post-laminated to a fluid-impervious backing layer to form an absorbent fluid barrier. The fluid-impervious backing layer could be a flexible polymeric film for use such absorbent articles as sanitary napkins, diapers, place mats, floor mats, protective covers, and the like.

One surprising beneficial characteristic of the laminate web structure of the present invention described with reference to FIG. 6 is the presence of distinct regions in the non-apertured portion of the web being differentiated by at least one property selected from the group consisting of basis weight, thickness, or density. As shown in the cross-section of FIG. 7, several such regions can be differentiated. In a preferred embodiment, the regions are visually distinct, giving the laminate an aesthetically pleasing look and feel. The regions may also give the laminate a garment-like or knit-like texture and hand.

With reference to FIG. 7, several structurally distinct regions can be identified in the cross-section shown. The region denoted **64** corresponds to the aperture **60**. In the non-apertured area of the web, a region **66** is a relatively high basis weight region comprising central layer **30**. Region **68** represents the portion of the laminate web in which central layer **30** has fractured and separated, *i.e.*, is no longer fully present, forming a relatively low basis weight region of web **10**. In general, the higher basis weight regions will also be correspondingly higher density regions, but need not be so. For example, a post-extension embossing process can be applied to web **10** to form regions of multiple densities in addition to the regions of multiple basis weight. For either the high basis weight regions or the high density regions, often the differences can be discernible by simply rubbing the laminate web between the fingers.

In general, for a laminate web **10** having generally parallel rows of melt bond sites **50** extending in the machine direction **MD**, which correspondingly form generally parallel rows of apertures when extended, and having a central layer with a lower elongation to break than the outer layers, the resulting extended, apertured laminate web **10** is characterized by generally low basis weight, low density regions between the apertures in the machine direction, **MD**, *e.g.*, region **68** in FIGs. 6 and 7. Likewise, such a laminate web **10** is characterized by relatively high basis weight, high density regions between

adjacent rows of apertures in the cross-machine direction, **CD**, *e.g.*, region **66** in FIG. 7. By choice of central layer material **30** and possibly post laminating operations, *e.g.*, an embossing process, the thickness of the laminate web can likewise be varied, the thicker regions generally corresponding to the higher density regions.

Another embodiment of a laminate web of the present invention utilizing nonwoven webs as the outer layers is characterized by distinct regions differentiated by fiber orientation. Differential fiber orientation can be achieved by providing for localized regions within the web that experience greater extension than other regions. For example, by locally straining the web **10** to a greater degree in the regions corresponding to regions **68** in FIG. 6, regions of significant fiber reorientation are formed. Such localized straining is possible by the method of the present invention detailed below.

FIG. 8 is a photomicrograph showing in magnified detail a web of the present invention comprising nonwoven outer layers which has been extended to form apertures, and locally extended to produce regions **68** of fiber reorientation. As can be seen in FIG. 8, by locally extending portions of the web to a greater extent than others, the apertures formed thereby can be of different sizes. Thus, the region denoted generally as **70** in FIG. 8 has undergone more strain (i.e., local extension) than the region denoted by **72**. Thus, the apertures in region **70** are larger than those in region **72**, and the basis weight of the nonwoven web material in region **72** is less than the basis weight of the nonwoven web in region **70**. In addition to the difference in basis weight due to localized strain differentials, the laminate web of the present invention can also exhibit distinct regions **68** of fiber reorientation. In these regions, the fibers have been reoriented from a generally random orientation to a predominant orientation in the direction of extension.

To make a web **10** as shown in FIG. 6, central layer **30** can be any of a great number of dissimilar materials. For example, if outer layers **20** and **40** are nonwoven webs having a relatively high elongation to break, central layer **30** can be paper, tissue paper, thermoplastic film, metal foil, closed or open cell foam, or any other material that has a relatively low elongation to break compared to the two outer layers. The outer layer materials may themselves be dissimilar, with the only constraint being that the central layer be relatively less extensible in the direction of extension to form apertures.

Additionally, more than one central layer **30** can be used with beneficial results. For example, a structure comprising a cellulosic tissue central web and a polymeric film central web between two nonwoven webs can produce an absorptive wiping article with one side being relatively more absorptive than the other. If the film layer is a three-dimensional formed film, the film side can provide added texture to the laminate that is beneficial in many wiping applications. Macroscopically-expanded, three-dimensional

formed films suitable for use in the present invention include those described in commonly-assigned U.S. Pat. No. 3,929,135 issued to Thompson on December 30, 1975, and U.S. Pat. No. 4,342,314 issued to Radel et al. on August 3, 1982, both patents hereby incorporated herein by reference.

The (or "a") central layer can also be elastomeric, and can be an elastomeric macroscopically-expanded, vacuum-formed, three-dimensional formed film, such as described in commonly-assigned U.S. Ser. No. 08/816,106, entitled "Tear Resistant Porous Extensible Web" filed by Curro et al. on March 14, 1997, and hereby incorporated herein by reference. Further, the (or "a") central layer can be a three-dimensional formed film having micro-apertures such as described in commonly-assigned U.S. Pat. No. 4,629,643 issued to Curro et al. on December 16, 1986, and 4,609,518, issued to Curro et al. on September 2, 1986, both of which are hereby incorporated herein by reference.

The (or "a") central layer can be a web material having a strainable network as disclosed in U.S. Pat. No. 5,518,801 issued to Chappell et al. on May 21, 1996, and hereby incorporated herein by reference. Such a web can be a structural elastic-like film (SELF) web, formed by, for example, embossing by mating plates or rolls.

The (or "a") central layer can be an absorbent open cell foam web material. Particularly suitable absorbent foams for high performance absorbent articles such as diapers have been made from High Internal Phase Emulsions (hereafter referred to as "HIPE"). See, for example, U.S. Patent 5,260,345 (DesMarais et al), issued November 9, 1993 and U.S. Patent 5,268,224 (DesMarais et al), issued December 7, 1993, hereby incorporated herein by reference. These absorbent HIPE foams provide desirable fluid handling properties, including: (a) relatively good wicking and fluid distribution characteristics to transport the imbibed urine or other body fluid away from the initial impingement zone and into other regions of the foam structure to allow for subsequent gushes of fluid to be accommodated; and (b) a relatively high storage capacity with a relatively high fluid capacity under load, i.e. under compressive forces.

The central layer **30** may comprise a gel substance, such as an absorbent gelling material. A gel substance is defined as a viscous substance which is capable of being processed in the encapsulation system of the present invention. The gel substance may be contained in or on a carrier layers. Examples of gel substances include supersorbers or hydrogel materials which may provide for superior absorbency when the laminate web of the present invention is used as an absorbent wipe or an absorbent core in a disposable absorbent article. By "hydrogel" as used herein is meant an inorganic or organic compound capable of absorbing aqueous fluids and retaining them under moderate pressures. For good results the hydrogels should be water insoluble. Examples are

inorganic materials such as silica gels and organic compounds such as cross-linked polymers. Cross-linking may be by covalent, ionic, vander Waals, or hydrogen bonding. Examples of polymers include polyacrylamides, polyvinyl alcohol, ethylene maleic anhydride copolymers, polyvinyl ethers, hydroxypropyl cellulose, carboxymethyl cellulose, polyvinyl pyridine and the like.

One benefit of the laminate of the present invention is the ability to make a laminate structure of dissimilar materials without the use of adhesive for joining. Because the central layer of the laminate web **10** is penetrated by the protuberances of the calendaring roll at melt bond sites, it can comprise non-thermally-bondable materials. The plurality of melt bond sites **50** are sufficient to keep the component webs together in the laminate web, so that the laminate web behaves as a unitary web for processing integrity and use, without unwanted delamination. However, in some embodiments, and for certain materials, it may be beneficial to apply adhesive between at least two of the constituent layers.

The laminate web of the present invention, being bonded by a plurality of relatively closely spaced thermal bond sites (without the use of thermoplastic adhesives) can be beneficially used for durable articles. For example, a laminate web of the present invention comprising nonwoven web outer layers and having a clothlike feel and appearance can be used in durable garments. Certain embodiments of the laminate web of the present invention can survive repeated washing and drying in household washing and drying equipment, depending on the component webs of the laminate, and the level of thermal bonding. Due to the knit-like or fabric-like look and feel of certain embodiments of the present invention, such durability can result in durable garment components such as interliners and the like.

METHOD OF MAKING

Referring to FIG. 9 there is schematically illustrated at **100** a process making a laminate web of the present invention.

A first web **120** which can be a relatively extensible web, is unwound from a supply roll **104** and travels in a direction indicated by the arrows associated therewith as the supply roll **104** rotates in the direction indicated by the arrows associated therewith. Likewise a second web **140**, which can be a relatively extensible web is unwound from supply roll **105**. A central layer **130**, which can be a relatively inextensible layer, is likewise drawn from supply roll **107**. The three components (or more, if more than one central layer is used) pass through a nip **106** of the thermal point bond roller arrangement **108** formed by rollers **110** and **112**.

Central layer can have a powdered, granular, particulate, or gel substance disposed in or on it. In one embodiment, central layer **130** is provided as a nonwoven web having particulate matter embedded therein. In another embodiment, central layer **130** is provided with powdered matter deposited on one surface thereof. In another embodiment, central layer **130** is provided having granular matter adhered to a surface thereof. In any event, the powdered, granular, particulate, or gel substance associated with central layer **130** is sufficiently immobilized such that upon processing as described herein, the substance is encapsulated by the first and second webs **120**, **140** after exiting the nip **106** of the thermal point bond roller arrangement **108**.

In another embodiment, a powdered, granular, particulate, or gel substance can be deposited on web **130** during laminate web manufacture. For example, a dispensing means **131** can facilitate deposition. Dispensing means **131** can be a hopper facilitating gravity feed of substances, or a sprayer facilitating forced feed of substances. Likewise, dispensing means **131** can be an extruder, a printer, a slot coater, a spreader, or equivalents and combinations of such deposition means. Likewise, dispensing means may include multiple means, such as an adhesive spray combined with a gravity feed deposition of a powdered substance.

In addition to thermoplastic nonwoven materials, either outer layer can comprise a polymeric film, for example a polyolefinic (e.g., PP or PE) thin film. If the entire outer layer is not uniformly thermoplastic, at least sufficient amounts to effect melt bonding must be thermoplastic. Conjugate fibers, such as bicomponent fibers can be used in the outer layers to facilitate thermal bonding of the outer layers. Either outer layer can comprise a formed film, such as a three-dimensional formed film having micro-apertures such as described in commonly-assigned U.S. Pat. No. 4,629,643 issued to Curro et al. on December 16, 1986, and 4,609,518, issued to Curro et al. on September 2, 1986, both of which are hereby incorporated herein by reference.

In a preferred embodiment, both outer layers comprise nonwoven materials, and may be the identical. The nonwoven material may be formed by known nonwoven extrusion processes, such as, for example, known meltblowing processes or known spunbonding processes, and passed directly through the nip **106** without first being bonded and/or stored on a supply roll. However, in a preferred embodiment, the nonwoven webs are themselves thermally point bonded (consolidated) webs commercially available on supply rolls. The thermal point bonds, which are typically in the form of a regular pattern of spaced-apart diamond shaped bond sites, are present in the nonwoven as purchased from a nonwoven vendor, and are to be distinguished in the web

of the present invention from the bond sites **50** formed by the method of the present invention.

The outer layer(s) may be elastic, highly elastic or nonelastic. The nonwoven web may be any melt-fusible web, including a spunbonded web, a meltblown web, or a bonded carded web. If the nonwoven web is a web of meltblown fibers, it may include meltblown microfibers. The nonwoven web may be made of fiber forming polymers such as, for example, polyolefins. Exemplary polyolefins include one or more of polypropylene, polyethylene, ethylene copolymers, propylene copolymers, and butene copolymers. The nonwoven web can have a basis weight between about 10 to about 60 grams per square meter (gsm), and more preferably about 15 to about 30 gsm.

The outer layers may themselves be a multilayer material having, for example, at least one layer of a spunbonded web joined to at least one layer of a meltblown web, a bonded carded web, or other suitable material. For example, the nonwoven web may be a multilayer web having a first layer of spunbonded polypropylene having a basis weight from about 0.2 to about 8 ounces per square yard, a layer of meltblown polypropylene having a basis weight from about 0.2 to about 4 ounces per square yard, and a second layer of spunbonded polypropylene having a basis weight from about 0.2 to about 8 ounces per square yard. Alternatively, the nonwoven web may be a single layer of material, such as, for example, a spunbonded web having a basis weight from about 0.2 to about 10 ounces per square yard or a meltblown web having a basis weight from about 0.2 to about 8 ounces per square yard.

The outer layers may also be a composite made up of a mixture of two or more different fibers or a mixture of fibers and particles. Such mixtures may be formed by adding fibers and/or particulates to the gas stream in which meltblown fibers or spunbond fibers are carried so that an intimate entangled co-mingling of fibers and other materials, e.g., wood pulp, staple fibers and particles occurs prior to collection of the fibers.

Prior to processing by the method of the present invention, a nonwoven web outer cover of fibers can be joined by bonding to form a coherent web structure. Suitable bonding techniques include, but are not limited to, chemical bonding, thermobonding, such as point calendering, hydroentangling, and needling. Further, prior to bonding, the webs **120**, **140** can be incrementally stretched as described below with respect to the laminate web. Such incremental stretching is commonly referred to as "ring rolling" and is referred to as such in Table 1 below.

Referring to FIGs. 9 and 10, the nonwoven thermal bond roller arrangement **108** preferably comprises a patterned calendar roller **110** and a smooth anvil roller **112**. One or both of the patterned calendar roller **110** and the smooth anvil roller **112** may be heated

and the temperature of either roller and the pressure between the two rollers may be adjusted by well known means to provide the desired temperature, if any, and pressure to concurrently displace central layer **30** at melt bond sites, and melt bond the two outer layers together at a plurality of bond sites.

The patterned calendar roller **110** is configured to have a circular cylindrical surface **114**, and a plurality of protuberances or pattern elements **116** which extend outwardly from surface **114**. The protuberances **116** are disposed in a predetermined pattern with each protuberance **116** being configured and disposed to displace central layer **30** at melt bond sites, and melt bond the two outer layers together at a plurality of locations. One pattern of protuberances is shown schematically in FIG. 11. As shown, the protuberances **116** have a relatively small width, **WP**, which can be between about 0.003 inches and 0.020 inches, but in a preferred embodiment is about 0.010 inches. Protuberances can have a length, **LP**, of between about 0.030 inches and about 0.200 inches, and in a preferred embodiment has a length of about 0.100 inches. In a preferred embodiment, the protuberances have an aspect ratio **(LP/WP)** of 10. The pattern shown is a regular repeating pattern of staggered protuberances, generally in rows, each separated by a row spacing, **RS**, of about between about 0.010 inches and about 0.200 inches. In a preferred embodiment, row spacing **RS** is about 0.060 inches. The protuberances can be spaced apart within a row by a protuberance spacing, **PS** generally equal to the protuberance length, **LP**. But the spacing and pattern can be varied in any way depending on the end product desired.

As shown in FIG. 10, patterned calendar roller **110** can have a repeating pattern of protuberances **116** which extend about the entire circumference of surface **114**. Alternatively, the protuberances **116** may extend around a portion, or portions of the circumference of surface **114**. Likewise, the protuberances **116** may be in a non-repeating pattern, or in a repeating pattern of randomly oriented protuberances. Of course, if randomly oriented, the opening of the resulting bond sites into apertures will also be somewhat random, depending on the orientation of the bond site with respect to the direction of tension, as discussed below. For example, if the web is tensioned in the cross-direction **(CD)** direction only, then the bond sites **50** having a longitudinal axis **l** with a vector component in the machine direction **(MD)** will open into an aperture, at least to the degree of the magnitude of such a vector component.

The protuberances **116** are preferably truncated conical shapes that extend radially outwardly from surface **114** and which have rectangular or somewhat elliptical distal end surfaces **117**. Although it is not intended to thereby limit the scope of the present invention to protuberances of only this configuration, it is currently believed that the high

aspect ratio of the melt bond site **50** is only achievable if the protuberances likewise have a narrow width and a high aspect ratio at the distal end surfaces **117**, as shown above with reference to FIG. 11. The roller **110** is preferably finished so that all of the end surfaces **117** lie in an imaginary right circular cylinder that is coaxial with respect to the axis of rotation of roller **110**.

The height of the protuberances should be selected according to the thickness of the laminate being bonded. In general, the height dimension should be greater than the maximum thickness of the laminate web during the calendaring process, so that adequate bonding occurs at the bond sites, and only at the bond sites.

Anvil roller **112**, is preferably a smooth surfaced, right circular cylinder of steel.

After passing through nip **106**, the three (or more) component webs **120**, **130**, and **140** have been formed into unitary laminate web **10**, thereby encapsulating substances associated with web **130**. At this point in the process the outer layers are thermally bonded to each other and unapertured, as shown in FIGs. 1 and 2. Central layer(s) **30**, from web **130**, is apertured, having been displaced by protuberances **116** in nip **106**. Depending on the central layer(s) used, it (they) may or may not participate in the bonding about the periphery of the bond sites. In some instances, particularly for non-thermoplastic, non-fibrous materials, central layer may not be involved in the bonding of the outer layers at all. However, for thermoplastic materials, and fibrous materials, some involvement of the central layer(s) is observed.

The laminate web **10** may be further processed to form apertures in the whole laminate web (or portions thereof) by extending portions of the web in a direction orthogonal to the axis **l** of bond sites **50**. Another way of describing the necessary extension to form apertures, is to say that to form apertures, it is necessary to apply sufficient force having a vector component parallel to the transverse axis **t** to effect fracture of the melt weakened region of bond sites **50**. As shown in FIGs. 9 and 10, the axis **l** is generally parallel to the machine direction **MD** of the web being processed. Therefore, extension in the cross-direction **CD** at the bonded portions has a component parallel to the transverse axis **t**, and causes the bond sites **50** to rupture and open to form apertures in the web.

One method for forming apertures uniformly across the web is to pass the web through nip **130** formed by an incremental stretching system **132** employing opposed pressure applicators **134** and **136** having three-dimensional surfaces which at least to a degree are complementary to one another. Stretching of the laminate web may be accomplished by other methods known in the art, including tentoring, or even by hand. However, to achieve even uniform aperturing across the web, and especially if localized

strain differentials are desired, the incremental stretching system disclosed herein is preferred.

Referring now to FIG. 12, there is shown a fragmentary enlarged view of the incremental stretching system **132** comprising incremental stretching rollers **134** and **136**. The incremental stretching roller **134** includes a plurality of teeth **160** and corresponding grooves **161** which extend about the entire circumference of roller **134**. Incremental stretching roller **136** includes a plurality of teeth **162** and a plurality of corresponding grooves **163**. The teeth **160** on roller **134** intermesh with or engage the grooves **163** on roller **136**, while the teeth **162** on roller **136** intermesh with or engage the grooves **161** on roller **134**. The teeth of each roller are generally triangular-shaped, as shown in FIG. 13. The apex of the teeth may be slightly rounded, if desired for certain effects in the finished web.

FIG. 13 shows a portion of the intermeshing of the teeth **160** and **162** of rollers **134** and **136**, respectively. The term "pitch" as used herein, refers to the distance between the apexes of adjacent teeth. The pitch can be between about 0.02 to about 0.30 inches, and is preferably between about 0.05 and about 0.15 inches. The height (or depth) of the teeth is measured from the base of the tooth to the apex of the tooth, and is preferably equal for all teeth. The height of the teeth can be between about 0.10 inches and 0.90 inches, and is preferably about 0.25 inches and 0.50 inches.

The teeth **160** in one roll can be offset by one-half the pitch from the teeth **162** in the other roll, such that the teeth of one roll (e.g., teeth **160**) mesh in the valley (e.g., valley **163**) between teeth in the mating roll. The offset permits intermeshing of the two rollers when the rollers are "engaged" or in an intermeshing, operative position relative to one another. In a preferred embodiment, the teeth of the respective rollers are only partially intermeshing. The degree to which the teeth on the opposing rolls intermesh is referred to herein as the "depth of engagement" or "DOE" of the teeth. As shown in FIG. 13, the DOE, **E**, is the distance between a position designated by plane **P1** where the apexes of the teeth on the respective rolls are in the same plane (0% engagement) to a position designated by plane **P2** where the apexes of the teeth of one roll extend inward beyond the plane **P1** toward the valley on the opposing roll. The optimum or effective DOE for particular laminate webs is dependent upon the height and the pitch of the teeth and the materials of the web.

In other embodiments the teeth of the mating rolls need not be aligned with the valleys of the opposing rolls. That is, the teeth may be out of phase with the valleys to some degree, ranging from slightly offset to greatly offset.

As the laminate web **10** having melt bonded locations **50** passes through the incremental stretching system **132** the laminate web **10** can be subjected to tensioning in the **CD** or cross-machine direction causing the laminate web **10** to be extended in the **CD** direction. Alternatively, or additionally, the laminate web **10** may be tensioned in the **MD** (machine direction). The tensioning force placed on the laminate web **10** can be adjusted (*e.g.*, by adjusting DOE) such that it causes the melt bonded locations **50** to separate or rupture creating a plurality of apertures **60** coincident with the melt bonded locations **50** in the laminate web **10**. However, portions of the melt bonds of the laminate web **10** remain, as indicated by portions **62** in FIG. 4, thereby maintaining the laminate web in a coherent, unitary web condition even after the melt bonded locations rupture.

After being subjected to the tensioning force applied by the incremental stretching system **132**, the laminate web **10** includes a plurality of apertures **60** which are coincident with the melt bonded regions **50** of the laminate web. As mentioned, a portion of the circumferential edges of apertures **60** include remnants **62** of the melt bonded locations **60**. It is believed that the remnants **60** help to resist further tearing or delamination of the laminate web. Remnants **62** may also contain portions of central layer **30**, to the extent that the central layer is involved in the bonding.

The use of rather brittle, or relatively still materials can be used as a central layer **30** with beneficial results when the laminate web is incrementally stretched as described herein. For example, thin ceramic materials having a relatively high stiffness can be used as central layer **30** in a laminate web **10** that is relatively highly flexible in at least one direction, depending on the direction of stretch. Therefore, if the web is incrementally stretched in the **CD** direction, the laminate web will be flexible about an axis parallel with the **MD** direction, and vice-versa. If the web is incrementally stretched in both directions, then the resulting laminate web **10** will be relatively highly flexible about two axes, and, depending on the size of the discrete "islands" of central layer produced, approaches the overall flexibility of the two outer layers.

EXAMPLES

The following examples are shown in Table 1 as exemplary of webs useful for the claimed invention. Because the choice of outer and inner layers and combinations is virtually infinite, the examples shown are meant to be illustrative of possible structures, and are not meant to be limiting to any particular material or structure. In particular, the examples shown are limited to currently preferred structures comprising nonwoven webs as the outer layers.

In Table 1 various combinations of materials are shown. The layers are numbered in order of structural proximity from one outer layer to the other. Therefore, layer 1 is always an outer layer, and the last numbered layer is likewise an outer layer.

For all the samples shown, the calendaring line speed was 100 feet per minute, but the line speed is not considered critical to the operation of the method. The calendaring pressure was 700 psig for all the samples, but the pressure can be varied as desired as long as bonding is achieved between the outer layers.

To form apertured embodiments of the samples below, the thermally bonded laminate was processed by the incremental stretching process as described above with reference to FIG. 12. For these samples a "Pitch" and depth of engagement ("DOE") are shown.

Clopay PE films were obtained from Clopay, Cincinnati, OH. These thin (about 0.001" thick) films are a soft and deformable polyethylene type, often used as fluid barrier materials for absorbent products.

Tredegar elastomeric formed films were obtained from Tredegar Film Products, Terre Haute, IN. By "formed film" is meant a macroscopically-expanded three-dimensional plastic web comprising a continuum of capillary networks originating in and extending from one surface of the web and terminating in the form of apertures in the opposite surface thereof. Such a formed film is disclosed in commonly assigned U.S. Pat. No. 4,342,314 issued to Radel et al. on Aug. 3, 1982. Elastomeric formed films are an improvement in the aforementioned Radel et al. web as disclosed in the above-mentioned commonly assigned, copending US patent application S.N. 08/816,106 entitled Tear Resistant Porous Extensible Web, filed March 14, 1997 in the name of Curro et al. Curro '106 discloses elasticized polymeric webs generally in accordance with the aforementioned Radel et al. patent that may be produced from elastomeric materials known in the art, and may be laminates of polymeric materials. Laminates of this type can be prepared by coextrusion of elastomeric materials and less elastic skin layers and may be used in the body hugging portions of absorbent garments, such as the waistband portions and leg cuffs.

High internal phase emulsion open cell foam materials can be made generally in accordance with the teachings of the above mentioned U.S. Patents 5,260,345 and U.S. Patent 5,268,224.

BBA and Corovin/BBA nonwovens were obtained form BBA, Greenville, SC.

BOUNTY® paper towels were obtained from The Procter & Gamble Co., Cincinnati, OH.

REYNOLD'S metal foil products were obtained from Reynold's Metal Products company.

3M products were obtained from 3M, Minneapolis, MN.

Other listed ingredients or components are commonly available ingredients, and the particular vendor is not considered essential to practicing the invention.

For the materials shown below, the basis weight is expressed in grams per square meter (gsm). Low density polyethylene is denoted "LDPE"; polypropylene is denoted as "PP"; and polyethylene is denoted as "PE". Spunbond is denoted as "SB".

Table 1: Examples of Laminate Webs of the Present Invention

Example No.	Layer 1	Layer 2	Layer 3	Layer 4	Layer 5	Roller Temp. Anvil/ Pattern (deg. F)	Pitch/ DOE (inches)
1	30 gsm LDPE SB nonwoven from Corovin/BBA	42 gsm BOUNTY® Paper Towel	30 gsm LDPE SB nonwoven from Corovin/BBA			250/270	
2	30 gsm LDPE SB nonwoven from Corovin/BBA	42 gsm BOUNTY® Paper Towel	42 gsm BOUNTY® Paper Towel	30 gsm LDPE SB nonwoven from Corovin/BBA		250/270	0.200/ 0.300
3	30 gsm LDPE SB nonwoven from Corovin/BBA	42 gsm BOUNTY® Paper Towel	30 gsm LDPE SB nonwoven from Corovin/BBA			250/270	0.060/ 0.850
4	80/20 (PE / PP) 30 gsm SB nonwoven from BBA	23 gsm PE film from Clopay	50/50 (PE / PP) 30 gsm SB nonwoven from BBA			275/295	
5	80/20 (PE / PP) 30 gsm SB nonwoven from BBA	23 gsm PE film from Clopay	50/50 (PE / PP) 30 gsm SB nonwoven from BBA			275/295	0.200/ 0.300
6	80/20 (PE / PP) 30 gsm SB nonwoven from BBA	42 gsm BOUNTY® Paper Towel	23 gsm PE film from Clopay	50/50 (PE / PP) 30 gsm SB nonwoven from BBA		275/295	
7	80/20 (PE / PP) 30 gsm SB nonwoven from BBA	42 gsm BOUNTY® Paper Towel	23 gsm PE film from Clopay	50/50 (PE / PP) 30 gsm SB nonwoven from BBA		275/295	0.200/ 0.300
8	30 gsm LDPE SB nonwoven from Corovin/BBA	M77 spray adhesive from 3M approx. 13	REYNOLDS® 65 gsm aluminum foil	M77 spray adhesive from 3M approx. 13	30 gsm LDPE SB nonwoven from Corovin/BBA	275/295	0.060/ 0.850

		gsm		gsm			
9	30 gsm LDPE SB nonwoven from Corovin/BBA	88 gsm elastomeric formed film from Tredegar	42 gsm BOUNTY® Paper Towel	30 gsm LDPE SB nonwoven from Corovin/BBA		250/270	0.200/ 0.300
10	30 gsm LDPE SB nonwoven from Corovin/BBA	Spray hot melt adhesive from Ato-Findley approx. 12 gsm	62 gsm High Internal Phase Emulsion open cell foam	Spray hot melt adhesive from Ato-Findley approx. 12 gsm	30 gsm LDPE SB nonwoven from Corovin/BBA	250/270	0.200/0.300
11	27 gsm high elongation carded PP nonwoven from BBA	42 gsm BOUNTY® Paper Towel	60 gsm laminate of 80/20 50/50 (PE / PP) nonwoven from BBA			295/350	0.060/0.110
12	31gsm Hydrophillic PP Carded Nonwoven	21gsm Bounty® Paper Towel	Na2SO4.10H2O Or CaCl2	21gsm Bounty ® Paper Towel	31gsm Hydrophobic PP Carded Nonwoven	325/325	
13	17gsm 50/50 (PE/PP) Bicomponent Spunbond Nonwoven from BBA	130gsm SAF airlaid web from Concord	17gsm 50/50 (PE/PP) Bicomponent Spunbond Nonwoven from BBA			230 /270	0.060/ .070
14	Ring Rolled 23gsm Bicomponent 60/40 (PE/Nylon) Spunbond Nonwoven from BBA	90gsm elastomeric formed film from Tredegar	Ring Rolled 23gsm Bicomponent 60/ 40 (PE/Nylon) Spunbond Nonwoven from BBA			285/270	0.060/ 0.065
15	Ring Rolled 30gsm Bicomponent 50/50 (PE/PP) Spunbond Nonwoven from BBA	90gsm elastomeric formed film from Tredegar	Ring Rolled 30gsm Bicomponent 50/50 (PE/PP) Spunbond Nonwoven from BBA			285/270	0.200/ 0.245
16	31gsm High Elongation Carded PP Nonwoven from BBA	63gsm Bounty® Paper Towel	31gsm High Elongation Carded PP Nonwoven from BBA			285/ 285	0.060/ 0.085
17	30 gsm 50/50 (PE/PP) Bicomponent Spunbond Nonwoven	PVC Heat Shrink Film (75gauge) from McMaster	PVC Heat Shrink Film (75gauge) from McMaster Carr	30 gsm 50/50 (PE/PP) Bicomponent Spunbond Nonwoven		237/248	0.060/ 0.105

	from BBA	Carr		from BBA			

The laminate webs of the present invention may be utilized in many varied applications. In most of the Examples shown above, one or more central layers **30** comprise apertures, pores, holes, or other openings in which powdered, granular, particulate, or gel substances can be beneficially disposed. In all the Examples shown above, a substance can be disposed on one or more central layers **30**. The applications are only limited by the available constituent ingredients or components included as, on, or in central layer **30**.

By way of example, laminates of the present invention can be useful as wipes, including wet wipes, shop wipes, facial wipes, and the like. For example, Example 3 having an absorbent cellulosic layer as central layer **30** and encapsulating cleaning ingredients in therein would be an excellent wipe for picking up spills and particulate matter that can be captured in the apertures. Likewise, Example 6, having a polyethylene film would be an excellent wipe for harsh jobs requiring a more durable wipe having extra scrubbing capability. A laminate of the present invention can be considered a durable or semi-durable rag or sponge for most purposes.

Metal-containing webs of the present invention can be used in electrical applications. For example, Example 8 in Table 1 can be used in applications requiring electrical shielding having a soft, compliant carrier material. A laminate similar to Example 8 may find use as a component in circuit boards, electrical cabling, and the like.

A laminate web of the present invention can find use as a filter for filtering and conditioning fluids. Air, for example, can be filtered and odorized by passing air through a suitably designed laminate web of the present invention having odor controlling particles encapsulated in central layer **30**. For example, electrostatic air filters can be made by laminating appropriate dissimilar polymeric nonwoven materials. In one embodiment the filter would comprise nonwoven materials of suitable material and pore size, and would be provided in an unstretched condition, that is, in a laminate such as that shown with respect to FIGs. 1 and 2. As the filter is used, and the pores become blocked with filtered debris, the tension placed on the filter media thereby would cause at least some of the bond sites **50** to open into apertures. At this event odor-containing substances such as a perfume-containing substances can release a smell giving a sensory perception that the filter should be changed. Thus, the filter comprises a self adjusting and automatic change-notice media that prevents complete blockage of the filter, and avoids overworking of blower motors and the like.

A laminate web of the present invention can be used to encapsulate food substances, such as food colorings, flavorings, nutrients, sweeteners, and the like. In one embodiment, for example, a substrate such as Examples 12 or 13 (depending on whether hydrophilic pulp is desired), can have encapsulated therein coffee flavor. The web could be supplied as a "tea" bag for individual cups of coffee eliminating the need to brew a pot or even multiple pots of coffees to obtain desired end flavors. The hydrophobicity/hydrophilicity of the component materials can be varied as desired to ensure controlled release of the various ingredients.

Other uses for laminates of the present invention include medical dressings, such as casting bandages or wraps. A cast material can be made by forming laminate having two nonwoven outer layers which encapsulate a plaster-forming, water-setting powder as, or on central layer **30**. A suitable powder is sold by Johnson & Johnson, Arlington, TX as FAST PLASTER®.

While particular embodiments of the present invention have been illustrated and described, it would be obvious to those skilled in the art that various other changes and modifications can be made without departing from the spirit and scope of the invention. It is therefore intended to cover in the appended claims all such changes and modifications that are within the scope of this invention.